US006249514B1

(12) **United States Patent**
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(10) **Patent No.: US 6,249,514 B1**
(45) **Date of Patent: Jun. 19, 2001**

(54) **SATELLITE DIRECT RADIO BROADCAST SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/124,997**

(22) Filed: **Jul. 30, 1998**

Related U.S. Application Data

(63) Continuation of application No. 08/569,346, filed on Dec. 8, 1995, now Pat. No. 5,835,487.

(51) **Int. Cl.**[7] **H04B 7/185**

(52) **U.S. Cl.** **370/316**; 370/319; 370/486; 348/6; 455/3.2; 455/12.1

(58) **Field of Search** 370/315, 316, 370/319, 321, 307, 330, 485, 486, 487; 455/4.1, 4.2, 5.1, 6.1, 6.2, 6.3, 13.3, 3.2, 12.1; 348/10, 11, 12, 13, 7, 6

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,789,142		1/1974	Shimasaki et al.	179/15
4,425,639		1/1984	Acampora et al.	370/50
4,480,328		10/1984	Alaria et al.	370/63
4,660,196		4/1987	Gray et al.	370/109
4,881,241		11/1989	Pommier et al.	375/38
4,901,310		2/1990	Ichiyoshi	370/75
4,922,483		5/1990	Kobayashi	370/50
4,931,802		6/1990	Assal et al.	342/356
5,191,576		3/1993	Pommier et al.	370/18
5,197,061		3/1993	Halbert-Lassalle	370/11
5,228,025		7/1993	Le Floch et al.	370/20
5,283,780		2/1994	Schuchman	370/50
5,299,192		3/1994	Guo et al.	370/70
5,303,393		4/1994	Noreen et al.	455/3.2
5,347,548		9/1994	Messerges	375/116
5,416,774		5/1995	Shigematsu	370/69.1
5,418,782		5/1995	Wasilewski	370/73
5,420,866	*	5/1995	Wasilewski	348/474
5,455,823		10/1995	Noreen et al.	370/50
5,473,601		12/1995	Rosen et al.	370/50
5,485,464		1/1996	Strodtbeck et al.	370/95.2
5,550,812		8/1996	Philips	370/19
5,555,547		9/1996	Lemaitre et al.	375/262
5,583,562		12/1996	Birch et al.	348/12
5,625,624		4/1997	Rosen et al.	370/307
5,682,195	*	10/1997	Hendricks et al.	348/6
5,689,245		11/1997	Noreen et al.	340/825.49
5,784,683	*	7/1998	Sistanizadeh et al.	455/5.1
5,845,088	*	12/1998	Lewis	348/13

OTHER PUBLICATIONS

S. Joseph Campanella, "Communications Satellites: Orbitting Into the 90's", *IEEE Spectrum*, pp. 49–52, Aug. 1990.

G. Losquadro, "Digital Audio Broadcasting: High–Grade Service Quality Through On–Board Processing Techniques", *SAT: Satellite Communications*, Jul. 31, 1995, pp. 1–9.

Maral, Gerard, *VSAT Networks*, pp. 52–53 (John Wiley & Sons, Ltd., 1995).

Chitre, D.M., "The Role of Satellite Communications in the ISDN Era", *International Journal of Satellite Communications*, vol. 10, No. 5, Sep.–Oct. 1992, pp. 210–215.

Chitre, D.M. et al, "Architectures for the Intelsat NISDN–Compatible Satellite Communications Network", *International Journal of Satellite Communications*, vol. 10, pp. 217–225 (1992).

The Eureka 147 Project, Digital Audio Broadcasting System, DAB Project Office, Germany, pp. 1–11.

Digital Audio Broadcast, Stanford Telecom, STEL–VPR–0538, Apr. 1991.

Proceedings from Second International Symposium on Digital Audio Broadcasting: the Sound of 2000, Toronto, Canada, Mar. 14–17, 1994, vol. II, pp. 63–108 and pp. 240–248.

Principles for the Guidance of EBU Members for WARC–92 Broadcasting–Satellite Service, European Broadcasting Union, Feb. 1991 Draft SPB 483–E, pp. 1–75.

Advanced Digital Techniques for UHF Satellite Sound Broadcasting: Collected Papers on Concepts for Sound Broadcasting Into the 21st Century, European Broadcasting Union, Extracted from the EBU Document SPB 442, Jan. 1998, pp. 11–69.

Annex C to ITU–R Special Publication on Terrestrial and Satellite Digital Sound Broadcasting to Vehicular Portable and Fixed Receivers in the VHF/UHF Bands on "Digital System B", Nov. 1, 1994.

Amendment to Communications Subsystem in Application of Satellite CD Radio Inc. before the Federal Communications Commission, pp. 1–16.

Le Floch et al, "Digital Sound Broadcasting to Mobile Receivers", *IEEE, Transactions on Consumer Electronics*, Aug. 1989, vol. 35, No. 3, pp. 493–503.

* cited by examiner

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(57) **ABSTRACT**

A satellite direct audio broadcast system includes a plurality of fixed-rate, uniform, frequency division multiple access ("FDMA") uplinks and a time division multiplexed ("TDM") downlink. Source audio channels may be divided among and transmitted through a selectable number of fixed-rate uplinks so as to have selectable audio quality at the receiver. Fixed-rate FDMA uplinks include information designating related channels as containing related source information. On-board the satellite baseband processing selects uplink information channels for inclusion into none, one or multiple TDM downlinks. Transmitted audio information may be scrambled, and authorization downloaded to receivers to permit descrambling for paid subscription service.

10 Claims, 7 Drawing Sheets

providing each of said channels with a control word, said control word comprising data selected from the group consisting of bits representing a number of related digital signal groups, each of said digital signal groups comprising a number of the plurality of channels, bits uniquely identifying the digital signal group to which one of the plurality of channels associated with the control word belongs, bits representing the number of the plurality of channels in the corresponding digital signal group, bits uniquely identifying the channel among the plurality of channels that corresponds to the control word, bits representing a number of sub-ensembles constituting at least one digital signal group, bits representing the number of the plurality of channels in a sub-ensemble, bits uniquely identifying a sub-ensemble, bits for indicating which of audio, video and data constitute a corresponding one of the plurality of channels, and blocking bits to prevent reception of at least sub-ensembles of selected ones of the plurality of channels by a receiver;

selectively routing said channels to at least one time division multiplexed downlink, the order and placement of said channels in said downlinks being predetermined; and

transporting said channels via said at least one time division multiplexed downlink to said receiver.

2. A communication system for broadcasting programs comprising at least one broadcast station configured to generate a plurality of channels, at least one of said programs to be broadcast being divided among a number of said channels, said broadcast station being operable to generate a time division multiplexed uplink comprising selected ones of said channels and a control word, said control word identifying a digital signal group to which a plurality of said selected ones of said channels belong and providing instructions to facilitate recombining of said selected ones of said channels during reception thereof, said broadcast station being programmable to selectively route said selected ones of said channels to said uplink such that the placement of said channels in said uplink is predetermined.

3. A communication system as claimed in claim 2, wherein said broadcast station is operable to generate a time division multiplexed second uplink and to control the routing of said channels to one of said uplink, said second uplink, both of said uplink and said second uplink, and neither of said uplink and said second uplink.

4. A communication system as claimed in claim 2, further comprising a space segment configured to frequency translate and repeat said uplink in a downlink.

5. A method of broadcasting programs from a plurality of sources comprising the steps of:

obtaining information signals corresponding to a program from at least one program source;

dividing said information signals of said program into a number of prime rate channels, each of said prime rate channels comprising a control word to identify which of said prime rate channels are related to the same said program to facilitate reception of said program; and

selectively routing said prime rate channels into a time division multiplexed uplink such that the placement and order of said prime rate channels in said uplink is predetermined.

6. A method as claimed in claim 5, further comprising the steps of:

repeating said uplink in a downlink via a space segment for reception at a radio receiver;

demultiplexing said downlink to recover said prime rate channels;

extracting said control words from said prime rate channels; and

recombining selected ones of said prime rate channels in accordance with said control words to recover said program.

7. A method as claimed in claim 6, further comprising the step of reducing error in said uplink prior to retransmission via said downlink.

8. A receiver in a broadcast communication system comprising:

an antenna and radio frequency front end for receiving a time division multiplexed downlink, said downlink comprising a plurality of prime rate channels, a program being broadcast by said communications system comprising at least one of said prime rate channels, the order and placement of said prime rate channels corresponding to said broadcast in said downlink being predetermined to facilitate reception thereof, said prime rate channels each comprising a control word providing instructions to said receiver to recombine said prime rate channels to recover said program;

a demultiplexer to recover said prime rate channels from said downlink in accordance with the predetermined order and placement of said prime rate channels therein;

an input device to allow a user to select said program;

a processor programmed to extract said prime rate channels having said control words which correspond to an output signal generated by said input device; and

an output device to playback said prime rate channels selected by said user.

9. A signal comprising broadcast information embodied in a carrier wave comprising:

a plurality of information channels comprising said broadcast information, said plurality of information channels being combined to create digital signal groups;

at least one control word, said control word comprising data selected from the group consisting of bits representing a number of related said digital signal groups, bits uniquely identifying the digital signal group to which a selected one of said information channels belongs, bits representing the number of said information channels in a corresponding one of said digital signal groups, and bits uniquely identifying a selected one of said information channels;

wherein said signal is multiplexed and the order and placement of said information channels in the multiplexed said signal is predetermined to facilitate identification of said information channels therein.

10. A signal as claimed in claim 9, wherein selected ones of said plurality of information channels are combined to create a sub-ensemble within one of said digital signal groups, said control word comprising data selected from the group consisting of bits representing a number of sub-ensembles within said one of said digital signal groups, bits representing the number of said information channels in one of said sub-ensembles, and bits uniquely identifying at least one of said sub-ensembles.

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